

**IN THE CLAIMS:**

The text of all pending claims, (including withdrawn claims) is set forth below. Cancelled and not entered claims are indicated with claim number and status only. The claims as listed below show added text with underlining and deleted text with ~~strike through~~. The status of each claim is indicated with one of (original), (currently amended), (cancelled), (withdrawn), (new), (previously presented), or (not entered).

Please AMEND claims 4-14, CANCEL claims 1-3, and ADD new claims 54-71 in accordance with the following:

1 (cancelled).

2 (cancelled).

3 (cancelled).

4 (currently amended): A pattern-center determination apparatus ~~as claimed in claim 4,~~

for determining a pattern center of a fingerprint-like pattern, which is formed with a number of pattern curves, said apparatus comprising:

an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

wherein said auxiliary-line generation section includes:

a start-point setting section for setting an arbitrary point of the fingerprint-like pattern as a start point;

a reference-circle generation section for generating a reference circle of a predetermined radius centered at the start point set by said start-point setting section;

a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the fingerprint-like pattern;

an intersecting-point extraction section for extracting those two of the intersecting points calculated by said reference-circle-intersecting-point calculation section which satisfy a predetermined condition;

an end-point calculation section for calculating a middle point of the two intersecting points extracted by said intersecting-point extraction section as an end point; and

a line-segment generation section for generating a line segment interconnecting the start point set by said start-point setting section and the end point calculated by said end-point calculation section;

wherein said start-point setting section is operable to set the end point as a new start point so that said reference-circle generation section, said reference-circle-intersecting-point calculation section, said intersecting-point extraction section, said end-point calculation section and said line-segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.

5 (currently amended): A pattern-center determination apparatus as claimed in claim-2-4, wherein said auxiliary-line generation section is operable to generate two auxiliary lines, and said pattern-center determination section is operable to determine an intersecting point at which the two auxiliary lines generated by said auxiliary-line generation section intersect with each other as the pattern center-said auxiliary-line generation section includes:

~~a start-point setting section for setting an arbitrary point of the fingerprint-like pattern as a start point;~~

~~a reference-circle generation section for generating a reference circle of a predetermined radius centered at the start point set by said start point setting section;~~

~~a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the fingerprint-like pattern;~~

~~an intersecting-point extraction section for extracting those two of the intersecting points calculated by said reference-circle-intersecting-point calculation section which satisfy a predetermined condition;~~

~~an end-point calculation section for calculating a middle point of the two intersecting points extracted by said intersecting-point extraction section as an end point; and~~

~~a line segment generation section for generating a line segment interconnecting the start point set by said start point setting section and the end point calculated by said end point calculation section;~~

~~wherein said start point setting section is operable to set the end point as a new start point so that said reference circle generation section, said reference circle intersecting point calculation section, said intersecting point extraction section, said end point calculation section and said line segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.~~

6 (currently amended): A pattern-center determination apparatus as claimed in claim 3-4, wherein said auxiliary-line generation section is operable to generate three or more auxiliary lines, and said pattern-center determination section includes an auxiliary-line-intersecting-point calculation section for calculating one or more intersecting points at which the three or more auxiliary lines generated by said auxiliary-line generation section intersect with each other, and a most-crowded-point calculation section for calculating a most crowded point, at which the intersecting points calculated by said auxiliary-line-intersecting-point calculation section are most crowded, so as to determine the calculated most crowded point as the pattern center ~~said auxiliary-line generation section includes:~~

~~a start point setting section for setting an arbitrary point of the fingerprint-like pattern as a start point;~~

~~a reference circle generation section for generating a reference circle of a predetermined radius centered at the start point set by said start point setting section;~~

~~a reference circle intersecting point calculation section for calculating intersecting points of the reference circle generated by said reference circle generation section and the pattern curves of the fingerprint-like pattern;~~

~~an intersecting point extraction section for extracting those two of the intersecting points calculated by said reference circle intersecting point calculation section which satisfy a predetermined condition;~~

~~an end point calculation section for calculating a middle point of the two intersecting points extracted by said intersecting point extraction section as an end point; and~~

~~a line segment generation section for generating a line segment interconnecting the start point set by said start point setting section and the end point calculated by said end point calculation section;~~

~~wherein said start point setting section is operable to set the end point as a new start~~

~~point so that said reference circle generation section, said reference circle intersecting point calculation section, said intersecting point extraction section, said end point calculation section and said line segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.~~

7 (currently amended): A pattern-center determination apparatus ~~as claimed in claim 1, for determining a pattern center of a fingerprint-like pattern, which is formed with a number of pattern curves, said apparatus comprising:~~

an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

wherein said auxiliary-line generation section includes:

a first-auxiliary-point setting section for setting two arbitrary points on an arbitrary one of pattern curves which form the fingerprint-like pattern as two first auxiliary points;

a start-point calculation section for calculating a middle point of the two first auxiliary points set by said first-auxiliary-point setting section as a start point;

an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two first auxiliary points set by said first-auxiliary-point setting section;

a perpendicular-bisector generation section for generating a perpendicular bisector to the auxiliary-line segment generated by said auxiliary-line-segment generation section;

a perpendicular-bisector-intersecting-point calculation section for calculating that one of intersecting points of the perpendicular bisector generated by said perpendicular-bisector generation section and the pattern curves of the fingerprint-like pattern which is present on a particular side with respect to the start point and positioned nearest to the start point;

a node calculation section for calculating a point on the perpendicular bisector spaced by a predetermined distance toward the particular side from the intersecting point calculated by said perpendicular-bisector-intersecting-point calculation section as a node;

a straight-line generation section for generating a straight line which passes the node

calculated by said node calculation section and intersects orthogonally with the perpendicular bisector;

a second-auxiliary-point calculation section for calculating those two of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which are on the opposite sides of the node and are positioned nearest to the node as second auxiliary points;

an end-point calculation section for calculating a middle point of the two second auxiliary points calculated by said second-auxiliary-point calculation section as an end point;

a first-line-segment generation section for generating a first line segment interconnecting the start point calculated by said start-point calculation section and the node calculated by said node calculation section; and

a second-line-segment generation section for generating a second line segment interconnecting the node calculated by said node calculation section and the end point calculated by said end-point calculation section;

wherein said first-auxiliary-point setting section is operable to set the two second auxiliary points as new first auxiliary points so that said start-point calculation section, said auxiliary-line-segment generation section, said perpendicular-bisector generation section, said perpendicular-bisector-intersecting-point calculation section, said node calculation section, said straight-line generation section, said second-auxiliary-point calculation section, said end-point calculation section, said first-line-segment generation section and said second-line-segment generation section repeatedly generate new first and second line segments, thereby generating the auxiliary line as a number of alternately successive first and second line segments.

8 (currently amended): A pattern-center determination apparatus as claimed in claim-2 7, wherein said auxiliary-line generation section is operable to generate two auxiliary lines, and said pattern-center determination section is operable to determine an intersecting point at which the two auxiliary lines generated by said auxiliary-line generation section intersect with each other as the pattern center ~~said auxiliary-line generation section includes:~~

~~a first-auxiliary-point setting section for setting two arbitrary points on an arbitrary one of pattern curves which form the fingerprint-like pattern as two first auxiliary points;~~

~~a start-point calculation section for calculating a middle point of the two first auxiliary points set by said first-auxiliary-point setting section as a start point;~~

~~an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two first auxiliary points set by said first-auxiliary-point setting section;~~

~~a perpendicular bisector generation section for generating a perpendicular bisector to the auxiliary line segment generated by said auxiliary line segment generation section;~~

~~a perpendicular bisector intersecting point calculation section for calculating that one of intersecting points of the perpendicular bisector generated by said perpendicular bisector generation section and the pattern curves of the fingerprint-like pattern which is present on a particular side with respect to the start point and positioned nearest to the start point;~~

~~a node calculation section for calculating a point on the perpendicular bisector spaced by a predetermined distance toward the particular side from the intersecting point calculated by said perpendicular bisector intersecting point calculation section as a node;~~

~~a straight line generation section for generating a straight line which passes the node calculated by said node calculation section and intersects orthogonally with the perpendicular bisector;~~

~~a second auxiliary point calculation section for calculating those two of intersecting points of the straight line generated by said straight line generation section and the pattern curves of the fingerprint-like pattern which are on the opposite sides of the node and are positioned nearest to the node as second auxiliary points;~~

~~an end point calculation section for calculating a middle point of the two second auxiliary points calculated by said second auxiliary point calculation section as an end point;~~

~~a first line segment generation section for generating a first line segment interconnecting the start point calculated by said start point calculation section and the node calculated by said node calculation section; and~~

~~a second line segment generation section for generating a second line segment interconnecting the node calculated by said node calculation section and the end point calculated by said end point calculation section;~~

~~wherein said first auxiliary point setting section is operable to set the two second auxiliary points as new first auxiliary points so that said start point calculation section, said auxiliary line segment generation section, said perpendicular bisector generation section, said perpendicular bisector intersecting point calculation section, said node calculation section, said straight line generation section, said second auxiliary point calculation section, said end point calculation section, said first line segment generation section and said second line segment generation section repeatedly generate new first and second line segments, thereby generating the auxiliary line as a number of alternately successive first and second line segments.~~

claim 3-7, wherein said auxiliary-line generation section is operable to generate three or more auxiliary lines, and said pattern-center determination section includes an auxiliary-line-intersecting-point calculation section for calculating one or more intersecting points at which the three or more auxiliary lines generated by said auxiliary-line generation section intersect with each other, and a most-crowded-point calculation section for calculating a most crowded point, at which the intersecting points calculated by said auxiliary-line-intersecting-point calculation section are most crowded, so as to determine the calculated most crowded point as the pattern center said auxiliary-line generation section includes:

~~a first auxiliary-point setting section for setting two arbitrary points on an arbitrary one of pattern curves which form the fingerprint-like pattern as two first auxiliary points;~~

~~a start-point calculation section for calculating a middle point of the two first auxiliary points set by said first auxiliary-point setting section as a start point;~~

~~an auxiliary-line segment generation section for generating an auxiliary-line segment interconnecting the two first auxiliary points set by said first auxiliary-point setting section;~~

~~a perpendicular-bisector generation section for generating a perpendicular bisector to the auxiliary-line segment generated by said auxiliary-line segment generation section;~~

~~a perpendicular-bisector-intersecting-point calculation section for calculating that one of intersecting points of the perpendicular bisector generated by said perpendicular-bisector generation section and the pattern curves of the fingerprint-like pattern which is present on a particular side with respect to the start point and positioned nearest to the start point;~~

~~a node calculation section for calculating a point on the perpendicular bisector spaced by a predetermined distance toward the particular side from the intersecting point calculated by said perpendicular-bisector-intersecting-point calculation section as a node;~~

~~a straight-line generation section for generating a straight line which passes the node calculated by said node calculation section and intersects orthogonally with the perpendicular bisector;~~

~~a second auxiliary-point calculation section for calculating those two of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which are on the opposite sides of the node and are positioned nearest to the node as second auxiliary points;~~

~~an end-point calculation section for calculating a middle point of the two second auxiliary points calculated by said second auxiliary-point calculation section as an end point;~~

~~a first-line segment generation section for generating a first-line segment interconnecting the start point calculated by said start-point calculation section and the node calculated by said~~

~~node calculation section; and~~

~~a second line segment generation section for generating a second line segment interconnecting the node calculated by said node calculation section and the end point calculated by said end point calculation section;~~

~~wherein said first auxiliary point setting section is operable to set the two second auxiliary points as new first auxiliary points so that said start point calculation section, said auxiliary line segment generation section, said perpendicular bisector generation section, said perpendicular bisector intersecting point calculation section, said node calculation section, said straight line generation section, said second auxiliary point calculation section, said end point calculation section, said first line segment generation section and said second line segment generation section repeatedly generate new first and second line segments, thereby generating the auxiliary line as a number of alternately successive first and second line segments.~~

10 (currently amended): A pattern-center determination apparatus ~~as claimed in claim 1, for determining a pattern center of a fingerprint-like pattern, which is formed with a number of pattern curves, said apparatus comprising:~~

an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

wherein said auxiliary-line generation section includes:

a start-point setting section for setting an arbitrary point on an arbitrary one of the pattern curves of the fingerprint-like pattern as a start point;

an auxiliary-point calculation section for calculating two points positioned on the pattern curve on which the start point set by said start-point setting section is present and spaced by a predetermined distance from the start point to the opposite sides along the pattern curve as auxiliary points;

an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two auxiliary points calculated by said auxiliary-point calculation section;



a straight-line generation section for generating a straight line which passes the start point set by said start-point setting section and intersects orthogonally with the auxiliary-line segment generated by said auxiliary-line-segment generation section;

an end-point calculation section for calculating that one of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which is positioned on a particular side with respect to the start point and nearest to the start point as an end point; and

a line-segment generation section for generating a line segment interconnecting the start point set by said start-point setting section and the end point calculated by said end-point calculation section;

wherein said start-point setting section is operable to set the end point as a new start point so that said auxiliary-point calculation section, said auxiliary-line-segment generation section, said straight-line generation section, said end-point calculation section and said line-segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.

11 (currently amended): A pattern-center determination apparatus as claimed in claim-2 4, wherein said auxiliary-line generation section is operable to generate two auxiliary lines, and said pattern-center determination section is operable to determine an intersecting point at which the two auxiliary lines generated by said auxiliary-line generation section intersect with each other as the pattern center ~~said auxiliary-line generation section includes:~~

~~a start-point setting section for setting an arbitrary point on an arbitrary one of the pattern curves of the fingerprint-like pattern as a start point;~~

~~an auxiliary-point calculation section for calculating two points positioned on the pattern curve on which the start point set by said start-point setting section is present and spaced by a predetermined distance from the start point to the opposite sides along the pattern curve as auxiliary points;~~

~~an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two auxiliary points calculated by said auxiliary-point calculation section;~~

~~a straight-line generation section for generating a straight line which passes the start point set by said start-point setting section and intersects orthogonally with the auxiliary-line segment generated by said auxiliary-line-segment generation section;~~

~~an end-point calculation section for calculating that one of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the~~

~~fingerprint-like pattern which is positioned on a particular side with respect to the start point and nearest to the start point as an end point; and~~

~~a line-segment generation section for generating a line segment interconnecting the start point set by said start-point setting section and the end point calculated by said end-point calculation section;~~

~~wherein said start-point setting section is operable to set the end point as a new start point so that said auxiliary-point calculation section, said auxiliary-line-segment generation section, said straight-line generation section, said end-point calculation section and said line-segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.~~

12 (currently amended): A pattern-center determination apparatus as claimed in claim 3-4, wherein said auxiliary-line generation section is operable to generate three or more auxiliary lines, and said pattern-center determination section includes an auxiliary-line-intersecting-point calculation section for calculating one or more intersecting points at which the three or more auxiliary lines generated by said auxiliary-line generation section intersect with each other, and a most-crowded-point calculation section for calculating a most crowded point, at which the intersecting points calculated by said auxiliary-line-intersecting-point calculation section are most crowded, so as to determine the calculated most crowded point as the pattern center said auxiliary-line generation section includes:

~~a start-point setting section for setting an arbitrary point on an arbitrary one of the pattern curves of the fingerprint-like pattern as a start point;~~

~~an auxiliary-point calculation section for calculating two points positioned on the pattern curve on which the start point set by said start-point setting section is present and spaced by a predetermined distance from the start point to the opposite sides along the pattern curve as auxiliary points;~~

~~an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two auxiliary points calculated by said auxiliary-point calculation section;~~

~~a straight-line generation section for generating a straight line which passes the start point set by said start-point setting section and intersects orthogonally with the auxiliary-line segment generated by said auxiliary-line-segment generation section;~~

~~an end-point calculation section for calculating that one of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which is positioned on a particular side with respect to the start point and~~

~~nearest to the start point as an end point; and~~

~~a line segment generation section for generating a line segment interconnecting the start point set by said start point setting section and the end point calculated by said end point calculation section;~~

~~wherein said start point setting section is operable to set the end point as a new start point so that said auxiliary point calculation section, said auxiliary line segment generation section, said straight line generation section, said end point calculation section and said line segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.~~

13 (currently amended): A pattern-center determination method for determining a pattern center of a fingerprint-like pattern, which is formed with a number of pattern curves, said method comprising the steps of:

generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments; and

determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines intersect with each other;

said step of determining includes

a start-point setting operation for setting an arbitrary point of the fingerprint-like pattern as a start point,

a reference-circle generation operation for generating a reference circle of a predetermined radius centered at the start point set by said start-point setting operation,

a reference-circle-intersecting-point calculation operation for calculating intersecting points of the reference circle generated by said reference-circle generation operation and the pattern curves of the fingerprint-like pattern,

an intersecting-point extraction operation for extracting those two of the intersecting points calculated by said reference-circle-intersecting-point calculation operation which satisfy a predetermined condition,

an end-point calculation operation for calculating a middle point of the two intersecting points extracted by said intersecting-point extraction operation as an end point, and

a line-segment generation operation for generating a line segment interconnecting the start point set by said start-point setting operation and the end point calculated by said end-point calculation operation;

wherein said start-point setting operation is operable to set the end point as a new start point so that said reference-circle generation operation, said reference-circle-intersecting-point calculation operation, said intersecting-point extraction operation, said end-point calculation operation and said line-segment generation operation repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.

14 (currently amended): A computer-readable recording medium on which a pattern-center determination program is recorded for use with a computer, said program being for determining a pattern center of a fingerprint-like pattern, which is formed with a number of pattern curves, and instructing the computer to function as:

an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

said auxiliary-line generation section including

a start-point setting section for setting an arbitrary point of the fingerprint-like pattern as a start point,

a reference-circle generation section for generating a reference circle of a predetermined radius centered at the start point set by said start-point setting section,

a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the fingerprint-like pattern,

an intersecting-point extraction section for extracting those two of the intersecting points calculated by said reference-circle-intersecting-point calculation section which satisfy a predetermined condition,

an end-point calculation section for calculating a middle point of the two intersecting

points extracted by said intersecting-point extraction section as an end point, and  
a line-segment generation section for generating a line segment interconnecting the start  
point set by said start-point setting section and the end point calculated by said end-point  
calculation section;  
wherein said start-point setting section is operable to set the end point as a new start  
point so that said reference-circle generation section, said reference-circle-intersecting-point  
calculation section, said intersecting-point extraction section, said end-point calculation section  
and said line-segment generation section repeatedly generate a new line segment, thereby  
generating the auxiliary line as a number of successive line segments.

15. (Original) A pattern-orientation determination apparatus for determining a pattern orientation of a fingerprint-like pattern, which is formed with a number of pattern curves, said apparatus comprising:

a pattern-center determination section for determining a pattern center of the fingerprint-like pattern;

a reference-circle generation section for generating a reference circle of a predetermined radius centered at the pattern center determined by said pattern-center determination section;

a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the fingerprint-like pattern;

a reference-point determination section for determining a reference point for the pattern orientation based on a relationship between directions of the reference circle and directions of the pattern curves at the intersecting points calculated by said reference-circle-intersecting-point calculation section; and

a pattern-orientation determination section for determining the pattern orientation based on the pattern center determined by said pattern-center determination section and the reference point determined by said reference-point determination section.

16. (Original) A pattern-orientation determination apparatus as claimed in claim 15, wherein said reference-point determination section includes:

an intersecting-point extraction section for extracting those two of the intersecting points calculated by said reference-circle-intersecting-point calculation section which satisfy a predetermined condition; and

a reference-point calculation section for calculating a middle point of the two intersecting

points extracted by said intersecting-point extraction section as the reference point.

17. (Original) A pattern-orientation determination apparatus as claimed in claim 15, wherein said pattern-orientation determination section includes a rectification section for rectifying the position of the pattern center based on those of the pattern curves which are present in the proximity of the pattern center, and said pattern-orientation determination section is operable to determine the direction of a reference straight line which passes the position of the pattern center rectified by said rectification section and the reference point as the pattern orientation.

18. (Original) A pattern-orientation determination apparatus as claimed in claim 16, wherein said pattern-orientation determination section includes a rectification section for rectifying the position of the pattern center based on those of the pattern curves which are present in the proximity of the pattern center, and said pattern-orientation determination section is operable to determine the direction of a reference straight line which passes the position of the pattern center rectified by said rectification section and the reference point as the pattern orientation.

19. (Original) A pattern-orientation determination apparatus according to claim 15, wherein said pattern-orientation determination section is operable to determine the direction of a reference straight line which passes the pattern center and the reference point as the pattern orientation.

20. (Original) A pattern-orientation determination apparatus according to claim 16, wherein said pattern-orientation determination section is operable to determine the direction of a reference straight line which passes the pattern center and the reference point as the pattern orientation.

21. (Original) A pattern-orientation determination apparatus according to claim 15, wherein said pattern-center determination section includes:

an auxiliary-line generation section for generating two or more auxiliary lines extending continuously from an outer circumference side one of the pattern curves of the fingerprint-like pattern toward an inner circumference side one of the pattern curves so that each of the auxiliary lines intersects each of the pattern curves perpendicularly or substantially perpendicularly; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points of the two or more auxiliary lines generated by said auxiliary-line generation section.

22. (Original) A pattern-orientation determination apparatus according to claim 16, wherein said pattern-center determination section includes:

an auxiliary-line generation section for generating two or more auxiliary lines extending continuously from an outer circumference side one of the pattern curves of the fingerprint-like pattern toward an inner circumference side one of the pattern curves so that each of the auxiliary lines intersects each of the pattern curves perpendicularly or substantially perpendicularly; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points of the two or more auxiliary lines generated by said auxiliary-line generation section.

23. (Original) A pattern-orientation determination apparatus according to claim 17, wherein said pattern-center determination section includes:

an auxiliary-line generation section for generating two or more auxiliary lines extending continuously from an outer circumference side one of the pattern curves of the fingerprint-like pattern toward an inner circumference side one of the pattern curves so that each of the auxiliary lines intersects each of the pattern curves perpendicularly or substantially perpendicularly; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points of the two or more auxiliary lines generated by said auxiliary-line generation section.

24. (Original) A pattern-orientation determination apparatus according to claim 18, wherein said pattern-center determination section includes:

an auxiliary-line generation section for generating two or more auxiliary lines extending continuously from an outer circumference side one of the pattern curves of the fingerprint-like pattern toward an inner circumference side one of the pattern curves so that each of the auxiliary lines intersects each of the pattern curves perpendicularly or substantially perpendicularly; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points of the two or more auxiliary lines generated by said auxiliary-line generation section.

25. (Original) A pattern-orientation determination apparatus according to claim 19, wherein said pattern-center determination section includes:

an auxiliary-line generation section for generating two or more auxiliary lines extending continuously from an outer circumference side one of the pattern curves of the fingerprint-like pattern toward an inner circumference side one of the pattern curves so that each of the auxiliary lines intersects each of the pattern curves perpendicularly or substantially perpendicularly; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points of the two or more auxiliary lines generated by said auxiliary-line generation section.

26. (Original) A pattern-orientation determination apparatus according to claim 20, wherein said pattern-center determination section includes:

an auxiliary-line generation section for generating two or more auxiliary lines extending continuously from an outer circumference side one of the pattern curves of the fingerprint-like pattern toward an inner circumference side one of the pattern curves so that each of the auxiliary lines intersects each of the pattern curves perpendicularly or substantially perpendicularly; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points of the two or more auxiliary lines generated by said auxiliary-line generation section.

27. (Original) A pattern-orientation determination method for determining a pattern orientation of a fingerprint-like pattern, which is formed with a number of pattern curves, said method comprising the steps of:

determining a pattern center of the fingerprint-like pattern;  
generating a reference circle of a predetermined radius centered at the pattern center;  
calculating intersecting points of the reference circle and the pattern curves of the fingerprint-like pattern;

determining a reference point for the pattern orientation based on a relationship between directions of the reference circle and directions of the pattern curves at the calculated intersecting points; and

determining the pattern orientation based on the pattern center and the reference point.

28. (Original) A computer-readable recording medium on which a pattern-orientation determination program is recorded for use with a computer, said program being for determining



a pattern orientation of a fingerprint-like pattern, which is formed with a number of pattern curves, and instructing the computer to function as:

- a pattern-center determination section for determining a pattern center of the fingerprint-like pattern;

- a reference-circle generation section for generating a reference circle of a predetermined radius centered at the pattern center determined by said pattern-center determination section;

- a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the fingerprint-like pattern;

- a reference-point determination section for determining a reference point for the pattern orientation based on a relationship between directions of the reference circle and directions of the pattern curves at the intersecting points calculated by said reference-circle-intersecting-point calculation section; and

- a pattern-orientation determination section for determining the pattern orientation based on the pattern center determined by said pattern-center determination section and the reference point determined by said reference-point determination section.

29 (currently amended): A pattern alignment apparatus for aligning two fingerprint-like patterns, each of which is formed with a number of pattern curves, said apparatus comprising:

- an alignment-reference determination section for determining one or more alignment references for each of the fingerprint-like patterns; and

- an alignment section for aligning the two fingerprint-like patterns so that the alignment references of the two fingerprint-like patterns determined by said alignment-reference determination section coincide with each other;

- said alignment-reference determination section including a pattern-center determination section for determining a pattern center of each of the fingerprint-like patterns as one of the alignment references, said pattern-center determination section having

- an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments, and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

said auxiliary-line generation section including

a start-point setting section for setting an arbitrary point of the fingerprint-like pattern as a start point,

a reference-circle generation section for generating a reference circle of a predetermined radius centered at the start point set by said start-point setting section,

a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the fingerprint-like pattern,

an intersecting-point extraction section for extracting those two of the intersecting points calculated by said reference-circle-intersecting-point calculation section which satisfy a predetermined condition,

an end-point calculation section for calculating a middle point of the two intersecting points extracted by said intersecting-point extraction section as an end point, and

a line-segment generation section for generating a line segment interconnecting the start point set by said start-point setting section and the end point calculated by said end-point calculation section;

wherein said start-point setting section is operable to set the end point as a new start point so that said reference-circle generation section, said reference-circle-intersecting-point calculation section, said intersecting-point extraction section, said end-point calculation section and said line-segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.

30 (currently amended): A pattern alignment apparatus ~~as claimed in claim 29, for~~ aligning two fingerprint-like patterns, each of which is formed with a number of pattern curves, said apparatus comprising:

an alignment-reference determination section for determining one or more alignment references for each of the fingerprint-like patterns; and

an alignment section for aligning the two fingerprint-like patterns so that the alignment references of the two fingerprint-like patterns determined by said alignment-reference determination section coincide with each other;

said alignment-reference determination section including a pattern-center determination

section for determining a pattern center of each of the fingerprint-like patterns as one of the alignment references, said pattern-center determination section having

an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments, and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

wherein said alignment-reference determination section further includes a pattern-orientation determination section for determining a pattern orientation of each of the fingerprint-like patterns as one of the alignment references, said pattern-orientation determination section having:

a reference-circle generation section for generating a reference circle of a predetermined radius centered at the pattern center determined by said pattern-center determination section;

a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the fingerprint-like pattern;

a reference-point determination section for determining a reference point for the pattern orientation based on a relationship between directions of the reference circle and directions of the pattern curves at the intersecting points calculated by said reference-circle-intersecting-point calculation section; and

a pattern-orientation determination section for determining the pattern orientation based on the pattern center determined by said pattern-center determination section and the reference point determined by said reference-point determination section.

31. (Original) A pattern alignment apparatus for aligning two fingerprint-like patterns, each of which is formed with a number of pattern curves, said apparatus comprising:

an alignment-reference determination section for determining one or more alignment references for each of the fingerprint-like patterns; and

an alignment section for aligning the two fingerprint-like patterns so that the alignment

references of the two fingerprint-like patterns determined by said alignment-reference determination section coincide with each other;

said alignment-reference determination section including a pattern-orientation determination section for determining a pattern orientation of each of the fingerprint-like patterns as one of the alignment references, said pattern-orientation determination section having a pattern-center determination section for determining a pattern center of each said fingerprint-like patterns as the alignment reference,

a reference-circle generation section for generating a reference circle of a predetermined radius centered at the pattern center determined by said pattern-center determination section,

a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of each said fingerprint-like pattern,

a reference-point determination section for determining a reference point for the pattern orientation based on a relationship between directions of the reference circle and directions of the pattern curves at the intersecting points calculated by said reference-circle-intersecting-point calculation section, and

a pattern-orientation determination section for determining the pattern orientation based on the pattern center determined by said pattern-center determination section and the reference point determined by said reference-point determination section.

32. (Previously Presented) A pattern alignment apparatus as claimed in claim 29, further comprising:

a minutia extraction section for extracting a group of minutiae from each of the two fingerprint-like patterns;

a collation section for collating the two group of minutiae extracted from the two fingerprint-like patterns by said minutia extraction section based on the alignment by said alignment section;

an adjustment-shift calculation section for calculating an adjustment shift of at least one of the two fingerprint-like patterns based on a result of the collation by said collation section so that the alignment of the two fingerprint-like patterns is improved; and

an alignment-result adjustment section for shifting at least one of the two fingerprint-like patterns by the adjustment shift calculated by said adjustment-shift calculation section so as to adjust a result of the alignment by said alignment section.

33. (Previously Presented) A pattern alignment apparatus as claimed in claim 30, further comprising:

a minutia extraction section for extracting a group of minutiae from each of the two fingerprint-like patterns;

a collation section for collating the two group of minutiae extracted from the two fingerprint-like patterns by said minutia extraction section based on the alignment by said alignment section;

an adjustment-shift calculation section for calculating an adjustment shift of at least one of the two fingerprint-like patterns based on a result of the collation by said collation section so that the alignment of the two fingerprint-like patterns is improved; and

an alignment-result adjustment section for shifting at least one of the two fingerprint-like patterns by the adjustment shift calculated by said adjustment-shift calculation section so as to adjust a result of the alignment by said alignment section.

34. (Previously Presented) A pattern alignment apparatus as claimed in claim 31, further comprising:

a minutia extraction section for extracting a group of minutiae from each of the fingerprint-like patterns;

a collation section for collating the two group of minutiae extracted from the two fingerprint-like patterns by said minutia extraction section based on the alignment by said alignment section;

an adjustment-shift calculation section for calculating an adjustment shift of at least one of the two fingerprint-like patterns based on a result of the collation by said collation section so that the alignment of the two fingerprint-like patterns is improved; and

an alignment-result adjustment section for shifting at least one of the two fingerprint-like patterns by the adjustment shift calculated by said adjustment-shift calculation section so as to adjust a result of the alignment by said alignment section.

35. (Original) A pattern alignment apparatus as claimed in claim 32, wherein the adjustment shift is at least one of a rotation angle by which one of the two fingerprint-like patterns is to be rotated around a predetermined point with respect to the other of the two fingerprint-like patterns and a shift by which one of the two fingerprint-like patterns is to be parallelly shifted with respect to the other of the two fingerprint-like patterns.

36. (Original) A pattern alignment apparatus as claimed in claim 33, wherein the adjustment shift is at least one of a rotation angle by which one of the two fingerprint-like patterns is to be rotated around a predetermined point with respect to the other of the two fingerprint-like patterns and a shift by which one of the two fingerprint-like patterns is to be parallelly shifted with respect to the other of the two fingerprint-like patterns.

37. (Original) A pattern alignment apparatus as claimed in claim 34, wherein the adjustment shift is at least one of a rotation angle by which one of the two fingerprint-like patterns is to be rotated around a predetermined point with respect to the other of the two fingerprint-like patterns and a shift by which one of the two fingerprint-like patterns is to be parallelly shifted with respect to the other of the two fingerprint-like patterns.

38 (currently amended): A pattern verification apparatus for verifying a group of object minutiae for verification extracted from an object fingerprint-like pattern for verification with a group of registered minutiae extracted in advance from a registered fingerprint-like pattern, each of the object fingerprint-like pattern and the registered fingerprint-like pattern being formed with the number of pattern curves, said apparatus comprising:

- a pattern inputting section for inputting the object fingerprint-like pattern;
- an alignment-reference determination section for determining one or more alignment references of the object fingerprint-like pattern inputted by said pattern inputting section;
- a minutia extraction section for extracting the group of object minutiae from the object fingerprint-like pattern inputted by said pattern inputting section;
- a registration-data obtaining section for obtaining registration data regarding the registered fingerprint-like pattern, said registration data including the group of registered minutiae and one or more alignment references of the registered fingerprint-like pattern;
- an alignment section for aligning the object fingerprint-like pattern or the group of object minutiae and the group of registered minutiae so that the alignment references of the object fingerprint-like pattern determined by said alignment-reference determination section and the alignment references of the registered fingerprint-like pattern obtained by said registration-data obtaining section coincide with each other; and
- a verification section for verifying the group of object minutiae with the group of registered minutiae based on the alignment by said alignment section;
- said alignment-reference determination section including a pattern-center determination section for determining a pattern center of the object fingerprint-like pattern as one of the

alignment references of the object fingerprint-like pattern,

the alignment references of the registered fingerprint-like pattern including a pattern center of the registered fingerprint-like pattern;

said pattern-center determination section including

an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments, and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

said auxiliary-line generation section including

a start-point setting section for setting an arbitrary point of the fingerprint-like pattern as a start point,

a reference-circle generation section for generating a reference circle of a predetermined radius centered at the start point set by said start-point setting section,

a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the fingerprint-like pattern,

an intersecting-point extraction section for extracting those two of the intersecting points calculated by said reference-circle-intersecting-point calculation section which satisfy a predetermined condition,

an end-point calculation section for calculating a middle point of the two intersecting points extracted by said intersecting-point extraction section as an end point, and

a line-segment generation section for generating a line segment interconnecting the start point set by said start-point setting section and the end point calculated by said end-point calculation section;

wherein said start-point setting section is operable to set the end point as a new start point so that said reference-circle generation section, said reference-circle-intersecting-point calculation section, said intersecting-point extraction section, said end-point calculation section and said line-segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.

39 (currently amended): A pattern verification apparatus ~~as claimed in claim 38, for~~ verifying a group of object minutiae for verification extracted from an object fingerprint-like pattern for verification with a group of registered minutiae extracted in advance from a registered fingerprint-like pattern, each of the object fingerprint-like pattern and the registered fingerprint-like pattern being formed with the number of pattern curves, said apparatus comprising:

- a pattern inputting section for inputting the object fingerprint-like pattern;
- an alignment-reference determination section for determining one or more alignment references of the object fingerprint-like pattern inputted by said pattern inputting section;
- a minutia extraction section for extracting the group of object minutiae from the object fingerprint-like pattern inputted by said pattern inputting section;
- a registration-data obtaining section for obtaining registration data regarding the registered fingerprint-like pattern, said registration data including the group of registered minutiae and one or more alignment references of the registered fingerprint-like pattern;
- an alignment section for aligning the object fingerprint-like pattern or the group of object minutiae and the group of registered minutiae so that the alignment references of the object fingerprint-like pattern determined by said alignment-reference determination section and the alignment references of the registered fingerprint-like pattern obtained by said registration-data obtaining section coincide with each other; and
- a verification section for verifying the group of object minutiae with the group of registered minutiae based on the alignment by said alignment section;
- said alignment-reference determination section including a pattern-center determination section for determining a pattern center of the object fingerprint-like pattern as one of the alignment references of the object fingerprint-like pattern,
- the alignment references of the registered fingerprint-like pattern including a pattern center of the registered fingerprint-like pattern;
- said pattern-center determination section including
- an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments, and
- a pattern-center determination section for determining the pattern center based on one or



more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

wherein said alignment-reference determination section further includes a pattern-orientation determination section for determining a pattern orientation of the fingerprint-like pattern for verification as one of the alignment references,

the alignment references of the registered fingerprint-like pattern including a pattern orientation of the registered fingerprint-like pattern, and

said pattern-orientation determination section includes

a reference-circle generation section for generating a reference circle of a predetermined radius centered at the pattern center determined by said pattern-center determination section,

a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the registered fingerprint-like pattern,

a reference-point determination section for determining a reference point for the pattern orientation based on a relationship between directions of the reference circle and directions of the pattern curves at the intersecting points calculated by said reference-circle-intersecting-point calculation section, and

a pattern-orientation determination section for determining the pattern orientation based on the pattern center determined by said pattern-center determination section and the reference point determined by said reference-point determination section.

40. (Original) A pattern verification apparatus for verifying a group of object minutiae extracted from an object fingerprint-like pattern for verification with a group of registered minutiae extracted in advance from a registered fingerprint-like pattern, each of the object fingerprint-like pattern and the registered fingerprint-like pattern being formed with the number of pattern curves, said apparatus comprising:

a pattern inputting section for inputting the object fingerprint-like pattern;

an alignment-reference determination section for determining one or more alignment references of the object fingerprint-like pattern inputted by said pattern inputting section;

a minutia extraction section for extracting the group of object minutiae from the object fingerprint-like pattern inputted by said pattern inputting section;

a registration-data obtaining section for obtaining registration data regarding the registered fingerprint-like pattern, said registration data including the group of registered minutiae and one or more alignment references of the registered fingerprint-like pattern;

an alignment section for aligning the object fingerprint-like pattern or the group of object minutiae and the group of registered minutiae so that the alignment references of the object fingerprint-like pattern determined by said alignment-reference determination section and the alignment references of the registered fingerprint-like pattern obtained by said registration-data obtaining section coincide with each other; and

a verification section for verifying the group of object minutiae with the group of registered minutiae based on the alignment by said alignment section;

said alignment-reference determination section including a pattern-orientation determination section for determining a pattern orientation of the object fingerprint-like pattern as one of the alignment references,

the registered alignment references of the registered fingerprint-like pattern including a pattern orientation of the registered fingerprint-like pattern;

said pattern-orientation determination section including

a pattern-center determination section for determining a pattern center of the object fingerprint-like pattern,

a reference-circle generation section for generating a reference circle of a predetermined radius centered at the pattern center of the object fingerprint-like pattern determined by said pattern-center determination section,

a reference-circle-intersecting-point calculation section for calculating intersecting points of the reference circle generated by said reference-circle generation section and the pattern curves of the object fingerprint-like pattern,

a reference-point determination section for determining a reference point for the pattern orientation based on a relationship between directions of the reference circle and directions of the pattern curves at the intersecting points calculated by said reference-circle-intersecting-point calculation section, and

a pattern-orientation determination section for determining the pattern orientation based on the pattern center determined by said pattern-center determination section and the reference point determined by said reference-point determination section.

41. (Original) A pattern verification apparatus as claimed in claim 38, wherein said pattern inputting section is operable to input the registered fingerprint-like pattern, said alignment-reference determination section is operable to determine the alignment references of the registered fingerprint-like pattern inputted by said pattern inputting section, said minutia extraction section is operable to extract the group of registered minutiae from the registered

fingerprint-like pattern inputted by said pattern inputting section, and said registration-data obtaining section is operable to obtain both the alignment references of the registered fingerprint-like pattern determined by said alignment-reference determination section and the group of registered minutiae extracted by said minutia extraction section as the registration data regarding the registered fingerprint-like pattern.

42. (Original) A pattern verification apparatus as claimed in claim 39, wherein said pattern inputting section is operable to input the registered fingerprint-like pattern, said alignment-reference determination section is operable to determine the alignment references of the registered fingerprint-like pattern inputted by said pattern inputting section, said minutia extraction section is operable to extract the group of registered minutiae from the registered fingerprint-like pattern inputted by said pattern inputting section, and said registration-data obtaining section is operable to obtain both the alignment references of the registered fingerprint-like pattern determined by said alignment-reference determination section and the group of registered minutiae extracted by said minutia extraction section as the registration data regarding the registered fingerprint-like pattern.

43. (Original) A pattern verification apparatus as claimed in claim 40, wherein said pattern inputting section is operable to input the registered fingerprint-like pattern, said alignment-reference determination section is operable to determine the alignment references of the registered fingerprint-like pattern inputted by said pattern inputting section, said minutia extraction section is operable to extract the group of registered minutiae from the registered fingerprint-like pattern inputted by said pattern inputting section, and said registration-data obtaining section is operable to obtain both the alignment references of the registered fingerprint-like pattern determined by said alignment-reference determination section and the group of registered minutiae extracted by said minutia extraction section as the registration data regarding the registered fingerprint-like pattern.

44. (Original) A pattern verification apparatus as claimed in claim 38, further comprising:

an adjustment-shift calculation section for calculating an adjustment shift of the group of object minutiae or/and the group of registered minutiae based on a result of the verification by said verification section so that the alignment of the group of object minutiae and the group of registered minutiae is improved; and

an alignment-result adjustment section for shifting the group of object minutiae or/and the group of registered minutiae by the adjustment shift calculated by said adjustment-shift calculation section so as to adjusting a result of the alignment by said alignment section;

said verification section being operable to output a result of the verification between the group of object minutiae and the group of registered minutiae based on the adjustment of the alignment result by said alignment-result adjustment section.

45. (Original) A pattern verification apparatus as claimed in claim 39, further comprising:

an adjustment-shift calculation section for calculating an adjustment shift of the group of object minutiae or/and the group of registered minutiae based on a result of the verification by said verification section so that the alignment of the group of object minutiae and the group of registered minutiae is improved; and

an alignment-result adjustment section for shifting the group of object minutiae or/and the group of registered minutiae by the adjustment shift calculated by said adjustment-shift calculation section so as to adjust a result of the alignment by said alignment section;

said verification section being operable to output a result of the verification between the group of object minutiae and the group of registered minutiae based on the adjustment of the alignment by said alignment-result adjustment section.

46. (Original) A pattern verification apparatus as claimed in claim 40, further comprising:

an adjustment-shift calculation section for calculating an adjustment shift of the group of object minutiae or/and the group of registered minutiae based on a result of the verification by said verification section so that the alignment of the group of object minutiae and the group of registered minutiae is improved; and

an alignment-result adjustment section for shifting the group of object minutiae or/and the group of registered minutiae by the adjustment shift calculated by said adjustment-shift calculation section so as to adjust a result of the alignment by said alignment section;

said verification section being operable to output a result of the verification between the group of object minutiae and the group of registered minutiae based on the adjustment of the alignment by said alignment-result adjustment section.

47. (Original) A pattern verification apparatus as claimed in claim 44, wherein the

adjustment shift is at least one of a rotation angle by which at least one of the group of object minutiae and the group of registered minutiae are to be rotated around a predetermined point with respect to the other of the two groups of minutiae and a shift by which at least one of the group of object minutiae and the group of registered minutiae are to be parallelly shifted with respect to the other of the two groups of minutiae.

48. (Original) A pattern verification apparatus as claimed in claim 45, wherein the adjustment shift is at least one of a rotation angle by which at least one of the group of object minutiae and the group of registered minutiae are to be rotated around a predetermined point with respect to the other of the two groups of minutiae and a shift by which at least one of the group of object minutiae and the group of registered minutiae are to be parallelly shifted with respect to the other of the two groups of minutiae.

49. (Original) A pattern verification apparatus as claimed in claim 46, wherein the adjustment shift is at least one of a rotation angle by which at least one of the group of object minutiae and the group of registered minutiae are to be rotated around a predetermined point with respect to the other of the two groups of minutiae and a shift by which at least one of the group of object minutiae and the group of registered minutiae are to be parallelly shifted with respect to the other of the two groups of minutiae.

50. (Cancelled)

51. (Previously Presented) A pattern alignment apparatus for aligning two fingerprint-like patterns, each of which is formed with a number of pattern curves, while adjusting the alignment of the two fingerprint-like patterns, comprising:

an alignment section for aligning the two fingerprint-like patterns;

a minutia extraction section for extracting a group of minutiae from each of the fingerprint-like patterns;

a collation section for collating the two groups of minutiae extracted from the two fingerprint-like patterns by said minutia extraction section, based on a result of the alignment by said alignment section;

an adjustment-shift calculation section for calculating an adjustment shift amount based on a result of the collation by said collation section, said adjustment shift amount being

determined in such a manner that when at least one of the two fingerprint-like patterns is shifted by said adjustment shift amount, the coincidence relationship between the two groups of minutiae collated by said collation section is improved;

an alignment-result adjustment section for shifting at least one of the two-fingerprint-like patterns by the adjustment shift amount calculated by said adjustment-shift calculation section so as to adjust the result of the alignment by said alignment section; and

a permissible-shift-range calculation section for calculating a permissible shift range, said permissible shift range being a shift range within which, when said collation section has discriminated that one or more minutiae of one of the two fingerprint-like patterns coincide with one or more minutiae of the other of the two fingerprint-like patterns respectively, one of the two fingerprint-like patterns can be shifted with respect to the other of the two fingerprint-like patterns while at least some of the one or more pairs of coinciding minutiae maintain the coincidence relationship,

said adjustment-shift calculation section being operable to calculate the adjustment shift within the permissible shift range calculated by said permissible-shift-range calculation section.

52. (Cancelled)

53. (Original) A pattern alignment apparatus as claimed in claim 51, wherein the adjustment shift is at least one of a rotation angle by which one of the two fingerprint-like patterns is to be rotated around a predetermined point with respect to the other of the two fingerprint-like patterns and a shift by which one of the two fingerprint-like patterns is to be parallelly shifted with respect to the other of the two fingerprint-like patterns.

54. (new): A pattern-center determination method for determining a pattern center of a fingerprint-like pattern, which is formed with a number of pattern curves, said method comprising the steps of:

generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments; and

determining the pattern center based on one or more intersecting points at which the two

or more auxiliary lines intersect with each other;

said step of determining includes

a first-auxiliary-point setting operation for setting two arbitrary points on an arbitrary one of pattern curves which form the fingerprint-like pattern as two first auxiliary points,

a start-point calculation operation for calculating a middle point of the two first auxiliary points set by said first-auxiliary-point setting operation as a start point,

an auxiliary-line-segment generation operation for generating an auxiliary-line segment interconnecting the two first auxiliary points set by said first-auxiliary-point setting operation,

a perpendicular-bisector generation operation for generating a perpendicular bisector to the auxiliary-line segment generated by said auxiliary-line-segment generation operation,

a perpendicular-bisector-intersecting-point calculation operation for calculating that one of intersecting points of the perpendicular bisector generated by said perpendicular-bisector generation operation and the pattern curves of the fingerprint-like pattern which is present on a particular side with respect to the start point and positioned nearest to the start point,

a node calculation operation for calculating a point on the perpendicular bisector spaced by a predetermined distance toward the particular side from the intersecting point calculated by said perpendicular-bisector-intersecting-point calculation operation as a node,

a straight-line generation operation for generating a straight line which passes the node calculated by said node calculation operation and intersects orthogonally with the perpendicular bisector,

a second-auxiliary-point calculation operation for calculating those two of intersecting points of the straight line generated by said straight-line generation operation and the pattern curves of the fingerprint-like pattern which are on the opposite sides of the node and are positioned nearest to the node as second auxiliary points,

an end-point calculation operation for calculating a middle point of the two second auxiliary points calculated by said second-auxiliary-point calculation operation as an end point,

a first-line-segment generation operation for generating a first line segment interconnecting the start point calculated by said start-point calculation operation and the node calculated by said node calculation operation, and

a second-line-segment generation operation for generating a second line segment interconnecting the node calculated by said node calculation operation and the end point calculated by said end-point calculation operation;

wherein said first-auxiliary-point setting operation is operable to set the two second auxiliary points as new first auxiliary points so that said start-point calculation operation, said

auxiliary-line-segment generation operation, said perpendicular-bisector generation operation, said perpendicular-bisector-intersecting-point calculation operation, said node calculation operation, said straight-line generation operation, said second-auxiliary-point calculation operation, said end-point calculation operation, said first-line-segment generation operation and said second-line-segment generation operation repeatedly generate new first and second line segments, thereby generating the auxiliary line as a number of alternately successive first and second line segments.

55. (new) A pattern-center determination method for determining a pattern center of a fingerprint-like pattern, which is formed with a number of pattern curves, said method comprising the steps of:

generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments; and

determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines intersect with each other;

said step of determining includes

a start-point setting operation for setting an arbitrary point on an arbitrary one of the pattern curves of the fingerprint-like pattern as a start point,

an auxiliary-point calculation operation for calculating two points positioned on the pattern curve on which the start point set by said start-point setting operation is present and spaced by a predetermined distance from the start point to the opposite sides along the pattern curve as auxiliary points,

an auxiliary-line-segment generation operation for generating an auxiliary-line segment interconnecting the two auxiliary points calculated by said auxiliary-point calculation operation,

a straight-line generation operation for generating a straight line which passes the start point set by said start-point setting operation and intersects orthogonally with the auxiliary-line segment generated by said auxiliary-line-segment generation operation,

an end-point calculation operation for calculating that one of intersecting points of the straight line generated by said straight-line generation operation and the pattern curves of the fingerprint-like pattern which is positioned on a particular side with respect to the start point and



nearest to the start point as an end point, and

a line-segment generation operation for generating a line segment interconnecting the start point set by said start-point setting operation and the end point calculated by said end-point calculation operation;

wherein said start-point setting operation is operable to set the end point as a new start point so that said auxiliary-point calculation operation, said auxiliary-line-segment generation operation, said straight-line generation operation, said end-point calculation operation and said line-segment generation operation repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.

56. (new) A computer-readable recording medium on which a pattern-center determination program is recorded for use with a computer, said program being for determining a pattern center of a fingerprint-like pattern, which is formed with a number of pattern curves, and instructing the computer to function as:

an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

said auxiliary-line generation section including

a first-auxiliary-point setting section for setting two arbitrary points on an arbitrary one of pattern curves which form the fingerprint-like pattern as two first auxiliary points,

a start-point calculation section for calculating a middle point of the two first auxiliary points set by said first-auxiliary-point setting section as a start point,

an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two first auxiliary points set by said first-auxiliary-point setting section,

a perpendicular-bisector generation section for generating a perpendicular bisector to the auxiliary-line segment generated by said auxiliary-line-segment generation section,

a perpendicular-bisector-intersecting-point calculation section for calculating that one of intersecting points of the perpendicular bisector generated by said perpendicular-bisector

generation section and the pattern curves of the fingerprint-like pattern which is present on a particular side with respect to the start point and positioned nearest to the start point,

a node calculation section for calculating a point on the perpendicular bisector spaced by a predetermined distance toward the particular side from the intersecting point calculated by said perpendicular-bisector-intersecting-point calculation section as a node,

a straight-line generation section for generating a straight line which passes the node calculated by said node calculation section and intersects orthogonally with the perpendicular bisector,

a second-auxiliary-point calculation section for calculating those two of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which are on the opposite sides of the node and are positioned nearest to the node as second auxiliary points,

an end-point calculation section for calculating a middle point of the two second auxiliary points calculated by said second-auxiliary-point calculation section as an end point,

a first-line-segment generation section for generating a first line segment interconnecting the start point calculated by said start-point calculation section and the node calculated by said node calculation section, and

a second-line-segment generation section for generating a second line segment interconnecting the node calculated by said node calculation section and the end point calculated by said end-point calculation section;

wherein said first-auxiliary-point setting section is operable to set the two second auxiliary points as new first auxiliary points so that said start-point calculation section, said auxiliary-line-segment generation section, said perpendicular-bisector generation section, said perpendicular-bisector-intersecting-point calculation section, said node calculation section, said straight-line generation section, said second-auxiliary-point calculation section, said end-point calculation section, said first-line-segment generation section and said second-line-segment generation section repeatedly generate new first and second line segments, thereby generating the auxiliary line as a number of alternately successive first and second line segments.

57. (new) A computer-readable recording medium on which a pattern-center determination program is recorded for use with a computer, said program being for determining a pattern center of a fingerprint-like pattern, which is formed with a number of pattern curves, and instructing the computer to function as:

an auxiliary-line generation section for generating a number of successive line segments

from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments; and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

said auxiliary-line generation section including

a start-point setting section for setting an arbitrary point on an arbitrary one of the pattern curves of the fingerprint-like pattern as a start point,

an auxiliary-point calculation section for calculating two points positioned on the pattern curve on which the start point set by said start-point setting section is present and spaced by a predetermined distance from the start point to the opposite sides along the pattern curve as auxiliary points,

an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two auxiliary points calculated by said auxiliary-point calculation section,

a straight-line generation section for generating a straight line which passes the start point set by said start-point setting section and intersects orthogonally with the auxiliary-line segment generated by said auxiliary-line-segment generation section,

an end-point calculation section for calculating that one of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which is positioned on a particular side with respect to the start point and nearest to the start point as an end point, and

a line-segment generation section for generating a line segment interconnecting the start point set by said start-point setting section and the end point calculated by said end-point calculation section;

wherein said start-point setting section is operable to set the end point as a new start point so that said auxiliary-point calculation section, said auxiliary-line-segment generation section, said straight-line generation section, said end-point calculation section and said line-segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.

58. (new) A pattern alignment apparatus for aligning two fingerprint-like patterns, each of

which is formed with a number of pattern curves, said apparatus comprising:

- an alignment-reference determination section for determining one or more alignment references for each of the fingerprint-like patterns; and

- an alignment section for aligning the two fingerprint-like patterns so that the alignment references of the two fingerprint-like patterns determined by said alignment-reference determination section coincide with each other;

- said alignment-reference determination section including a pattern-center determination section for determining a pattern center of each of the fingerprint-like patterns as one of the alignment references, said pattern-center determination section having

- an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments, and

- a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

- said auxiliary-line generation section including

- a first-auxiliary-point setting section for setting two arbitrary points on an arbitrary one of pattern curves which form the fingerprint-like pattern as two first auxiliary points,

- a start-point calculation section for calculating a middle point of the two first auxiliary points set by said first-auxiliary-point setting section as a start point,

- an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two first auxiliary points set by said first-auxiliary-point setting section,

- a perpendicular-bisector generation section for generating a perpendicular bisector to the auxiliary-line segment generated by said auxiliary-line-segment generation section,

- a perpendicular-bisector-intersecting-point calculation section for calculating that one of intersecting points of the perpendicular bisector generated by said perpendicular-bisector generation section and the pattern curves of the fingerprint-like pattern which is present on a particular side with respect to the start point and positioned nearest to the start point,

- a node calculation section for calculating a point on the perpendicular bisector spaced by a predetermined distance toward the particular side from the intersecting point calculated by said perpendicular-bisector-intersecting-point calculation section as a node,

a straight-line generation section for generating a straight line which passes the node calculated by said node calculation section and intersects orthogonally with the perpendicular bisector,

a second-auxiliary-point calculation section for calculating those two of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which are on the opposite sides of the node and are positioned nearest to the node as second auxiliary points,

an end-point calculation section for calculating a middle point of the two second auxiliary points calculated by said second-auxiliary-point calculation section as an end point,

a first-line-segment generation section for generating a first line segment interconnecting the start point calculated by said start-point calculation section and the node calculated by said node calculation section, and

a second-line-segment generation section for generating a second line segment interconnecting the node calculated by said node calculation section and the end point calculated by said end-point calculation section;

wherein said first-auxiliary-point setting section is operable to set the two second auxiliary points as new first auxiliary points so that said start-point calculation section, said auxiliary-line-segment generation section, said perpendicular-bisector generation section, said perpendicular-bisector-intersecting-point calculation section, said node calculation section, said straight-line generation section, said second-auxiliary-point calculation section, said end-point calculation section, said first-line-segment generation section and said second-line-segment generation section repeatedly generate new first and second line segments, thereby generating the auxiliary line as a number of alternately successive first and second line segments.

59. (new) A pattern alignment apparatus as claimed in claim 57, further comprising:  
a minutia extraction section for extracting a group of minutiae from each of the two fingerprint-like patterns;

a collation section for collating the two group of minutiae extracted from the two fingerprint-like patterns by said minutia extraction section based on the alignment by said alignment section;

an adjustment-shift calculation section for calculating an adjustment shift of at least one of the two fingerprint-like patterns based on a result of the collation by said collation section so that the alignment of the two fingerprint-like patterns is improved; and

a alignment-result adjustment section for shifting at least one of the two fingerprint-like

patterns by the adjustment shift calculated by said adjustment-shift calculation section so as to adjust a result of the alignment by said alignment section.

60. (new) A pattern alignment apparatus as claimed in claim 58, wherein the adjustment shift is at least one of a rotation angle by which one of the two fingerprint-like patterns is to be rotated around a predetermined point with respect to the other of the two fingerprint-like patterns and a shift by which one of the two fingerprint-like patterns is to be parallelly shifted with respect to the other of the two fingerprint-like patterns.

61. (new) A pattern alignment apparatus for aligning two fingerprint-like patterns, each of which is formed with a number of pattern curves, said apparatus comprising:

an alignment-reference determination section for determining one or more alignment references for each of the fingerprint-like patterns; and

an alignment section for aligning the two fingerprint-like patterns so that the alignment references of the two fingerprint-like patterns determined by said alignment-reference determination section coincide with each other;

said alignment-reference determination section including a pattern-center determination section for determining a pattern center of each of the fingerprint-like patterns as one of the alignment references, said pattern-center determination section having

an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments, and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

said auxiliary-line generation section including

a start-point setting section for setting an arbitrary point on an arbitrary one of the pattern curves of the fingerprint-like pattern as a start point,

an auxiliary-point calculation section for calculating two points positioned on the pattern curve on which the start point set by said start-point setting section is present and spaced by a predetermined distance from the start point to the opposite sides along the pattern curve as

auxiliary points,

an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two auxiliary points calculated by said auxiliary-point calculation section,

a straight-line generation section for generating a straight line which passes the start point set by said start-point setting section and intersects orthogonally with the auxiliary-line segment generated by said auxiliary-line-segment generation section,

an end-point calculation section for calculating that one of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which is positioned on a particular side with respect to the start point and nearest to the start point as an end point, and

a line-segment generation section for generating a line segment interconnecting the start point set by said start-point setting section and the end point calculated by said end-point calculation section;

wherein said start-point setting section is operable to set the end point as a new start point so that said auxiliary-point calculation section, said auxiliary-line-segment generation section, said straight-line generation section, said end-point calculation section and said line-segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.

62. (new) A pattern alignment apparatus as claimed in claim 60, further comprising:

a minutia extraction section for extracting a group of minutiae from each of the two fingerprint-like patterns;

a collation section for collating the two group of minutiae extracted from the two fingerprint-like patterns by said minutia extraction section based on the alignment by said alignment section;

an adjustment-shift calculation section for calculating an adjustment shift of at least one of the two fingerprint-like patterns based on a result of the collation by said collation section so that the alignment of the two fingerprint-like patterns is improved; and

a alignment-result adjustment section for shifting at least one of the two fingerprint-like patterns by the adjustment shift calculated by said adjustment-shift calculation section so as to adjust a result of the alignment by said alignment section.

63. (new) A pattern alignment apparatus as claimed in claim 61, wherein the adjustment shift is at least one of a rotation angle by which one of the two fingerprint-like

patterns is to be rotated around a predetermined point with respect to the other of the two fingerprint-like patterns and a shift by which one of the two fingerprint-like patterns is to be parallelly shifted with respect to the other of the two fingerprint-like patterns.

64. (new) A pattern verification apparatus for verifying a group of object minutiae for verification extracted from an object fingerprint-like pattern for verification with a group of registered minutiae extracted in advance from a registered fingerprint-like pattern, each of the object fingerprint-like pattern and the registered fingerprint-like pattern being formed with the number of pattern curves, said apparatus comprising:

- a pattern inputting section for inputting the object fingerprint-like pattern;
  - an alignment-reference determination section for determining one or more alignment references of the object fingerprint-like pattern inputted by said pattern inputting section;
  - a minutia extraction section for extracting the group of object minutiae from the object fingerprint-like pattern inputted by said pattern inputting section;
  - a registration-data obtaining section for obtaining registration data regarding the registered fingerprint-like pattern, said registration data including the group of registered minutiae and one or more alignment references of the registered fingerprint-like pattern;
  - an alignment section for aligning the object fingerprint-like pattern or the group of object minutiae and the group of registered minutiae so that the alignment references of the object fingerprint-like pattern determined by said alignment-reference determination section and the alignment references of the registered fingerprint-like pattern obtained by said registration-data obtaining section coincide with each other; and
  - a verification section for verifying the group of object minutiae with the group of registered minutiae based on the alignment by said alignment section;
- said alignment-reference determination section including a pattern-center determination section for determining a pattern center of the object fingerprint-like pattern as one of the alignment references of the object fingerprint-like pattern,
- the alignment references of the registered fingerprint-like pattern including a pattern center of the registered fingerprint-like pattern;
- said pattern-center determination section including
- an auxiliary-line generation section for generating a number of successive line segments from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially



perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments, and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

said auxiliary-line generation section including

a first-auxiliary-point setting section for setting two arbitrary points on an arbitrary one of pattern curves which form the fingerprint-like pattern as two first auxiliary points,

a start-point calculation section for calculating a middle point of the two first auxiliary points set by said first-auxiliary-point setting section as a start point,

an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two first auxiliary points set by said first-auxiliary-point setting section,

a perpendicular-bisector generation section for generating a perpendicular bisector to the auxiliary-line segment generated by said auxiliary-line-segment generation section,

a perpendicular-bisector-intersecting-point calculation section for calculating that one of intersecting points of the perpendicular bisector generated by said perpendicular-bisector generation section and the pattern curves of the fingerprint-like pattern which is present on a particular side with respect to the start point and positioned nearest to the start point,

a node calculation section for calculating a point on the perpendicular bisector spaced by a predetermined distance toward the particular side from the intersecting point calculated by said perpendicular-bisector-intersecting-point calculation section as a node,

a straight-line generation section for generating a straight line which passes the node calculated by said node calculation section and intersects orthogonally with the perpendicular bisector,

a second-auxiliary-point calculation section for calculating those two of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which are on the opposite sides of the node and are positioned nearest to the node as second auxiliary points,

an end-point calculation section for calculating a middle point of the two second auxiliary points calculated by said second-auxiliary-point calculation section as an end point,

a first-line-segment generation section for generating a first line segment interconnecting the start point calculated by said start-point calculation section and the node calculated by said node calculation section, and

a second-line-segment generation section for generating a second line segment

interconnecting the node calculated by said node calculation section and the end point calculated by said end-point calculation section;

wherein said first-auxiliary-point setting section is operable to set the two second auxiliary points as new first auxiliary points so that said start-point calculation section, said auxiliary-line-segment generation section, said perpendicular-bisector generation section, said perpendicular-bisector-intersecting-point calculation section, said node calculation section, said straight-line generation section, said second-auxiliary-point calculation section, said end-point calculation section, said first-line-segment generation section and said second-line-segment generation section repeatedly generate new first and second line segments, thereby generating the auxiliary line as a number of alternately successive first and second line segments.

65. (new) A pattern verification apparatus as claimed in claim 63, wherein said pattern inputting section is operable to input the registered fingerprint-like pattern, said alignment-reference determination section is operable to determine the alignment references of the registered fingerprint-like pattern inputted by said pattern inputting section, said minutia extraction section is operable to extract the group of registered minutiae from the registered fingerprint-like pattern inputted by said pattern inputting section, and said registration-data obtaining section is operable to obtain both the alignment references of the registered fingerprint-like pattern determined by said alignment-reference determination section and the group of registered minutiae extracted by said minutia extraction section as the registration data regarding the registered fingerprint-like pattern.

66. (new) A pattern verification apparatus as claimed in claim 63, further comprising:  
an adjustment-shift calculation section for calculating an adjustment shift of the group of object minutiae or/and the group of registered minutiae based on a result of the verification by said verification section so that the alignment of the group of object minutiae and the group of registered minutiae is improved; and  
an alignment-result adjustment section for shifting the group of object minutiae or/and the group of registered minutiae by the adjustment shift calculated by said adjustment-shift calculation section so as to adjusting a result of the alignment by said alignment section;  
said verification section being operable to output a result of the verification between the group of object minutiae and the group of registered minutiae based on the adjustment of the alignment result by said alignment-result adjustment section.

67. (new) A pattern verification apparatus as claimed in claim 65, wherein the adjustment shift is at least one of a rotation angle by which at least one of the group of object minutiae and the group of registered minutiae are to be rotated around a predetermined point with respect to the other of the two groups of minutiae and a shift by which at least one of the group of object minutiae and the group of registered minutiae are to be parallelly shifted with respect to the other of the two groups of minutiae.

68. (new) A pattern verification apparatus for verifying a group of object minutiae for verification extracted from an object fingerprint-like pattern for verification with a group of registered minutiae extracted in advance from a registered fingerprint-like pattern, each of the object fingerprint-like pattern and the registered fingerprint-like pattern being formed with the number of pattern curves, said apparatus comprising:

- a pattern inputting section for inputting the object fingerprint-like pattern;
  - an alignment-reference determination section for determining one or more alignment references of the object fingerprint-like pattern inputted by said pattern inputting section;
  - a minutia extraction section for extracting the group of object minutiae from the object fingerprint-like pattern inputted by said pattern inputting section;
  - a registration-data obtaining section for obtaining registration data regarding the registered fingerprint-like pattern, said registration data including the group of registered minutiae and one or more alignment references of the registered fingerprint-like pattern;
  - an alignment section for aligning the object fingerprint-like pattern or the group of object minutiae and the group of registered minutiae so that the alignment references of the object fingerprint-like pattern determined by said alignment-reference determination section and the alignment references of the registered fingerprint-like pattern obtained by said registration-data obtaining section coincide with each other; and
  - a verification section for verifying the group of object minutiae with the group of registered minutiae based on the alignment by said alignment section;
- said alignment-reference determination section including a pattern-center determination section for determining a pattern center of the object fingerprint-like pattern as one of the alignment references of the object fingerprint-like pattern,
- the alignment references of the registered fingerprint-like pattern including a pattern center of the registered fingerprint-like pattern;
- said pattern-center determination section including
- an auxiliary-line generation section for generating a number of successive line segments

from an outer circumference side of the pattern curves of the fingerprint-like pattern toward an inner circumference side of the pattern curves in such a manner that each of the line segments intersects each a respective one of the pattern curves perpendicularly or substantially perpendicularly two or more auxiliary lines, thereby generating two or more auxiliary lines each of which consists of the successive line segments, and

a pattern-center determination section for determining the pattern center based on one or more intersecting points at which the two or more auxiliary lines generated by said auxiliary-line generation section intersect with each other;

said auxiliary-line generation section including

a start-point setting section for setting an arbitrary point on an arbitrary one of the pattern curves of the fingerprint-like pattern as a start point,

an auxiliary-point calculation section for calculating two points positioned on the pattern curve on which the start point set by said start-point setting section is present and spaced by a predetermined distance from the start point to the opposite sides along the pattern curve as auxiliary points,

an auxiliary-line-segment generation section for generating an auxiliary-line segment interconnecting the two auxiliary points calculated by said auxiliary-point calculation section,

a straight-line generation section for generating a straight line which passes the start point set by said start-point setting section and intersects orthogonally with the auxiliary-line segment generated by said auxiliary-line-segment generation section,

an end-point calculation section for calculating that one of intersecting points of the straight line generated by said straight-line generation section and the pattern curves of the fingerprint-like pattern which is positioned on a particular side with respect to the start point and nearest to the start point as an end point, and

a line-segment generation section for generating a line segment interconnecting the start point set by said start-point setting section and the end point calculated by said end-point calculation section;

wherein said start-point setting section is operable to set the end point as a new start point so that said auxiliary-point calculation section, said auxiliary-line-segment generation section, said straight-line generation section, said end-point calculation section and said line-segment generation section repeatedly generate a new line segment, thereby generating the auxiliary line as a number of successive line segments.

69. (new) A pattern verification apparatus as claimed in claim 67, wherein said

pattern inputting section is operable to input the registered fingerprint-like pattern, said alignment-reference determination section is operable to determine the alignment references of the registered fingerprint-like pattern inputted by said pattern inputting section, said minutia extraction section is operable to extract the group of registered minutiae from the registered fingerprint-like pattern inputted by said pattern inputting section, and said registration-data obtaining section is operable to obtain both the alignment references of the registered fingerprint-like pattern determined by said alignment-reference determination section and the group of registered minutiae extracted by said minutia extraction section as the registration data regarding the registered fingerprint-like pattern.

70. (new) A pattern verification apparatus as claimed in claim 67, further comprising:  
an adjustment-shift calculation section for calculating an adjustment shift of the group of object minutiae or/and the group of registered minutiae based on a result of the verification by said verification section so that the alignment of the group of object minutiae and the group of registered minutiae is improved; and  
an alignment-result adjustment section for shifting the group of object minutiae or/and the group of registered minutiae by the adjustment shift calculated by said adjustment-shift calculation section so as to adjusting a result of the alignment by said alignment section;  
said verification section being operable to output a result of the verification between the group of object minutiae and the group of registered minutiae based on the adjustment of the alignment result by said alignment-result adjustment section.

71. (new) A pattern verification apparatus as claimed in claim 67, wherein the adjustment shift is at least one of a rotation angle by which at least one of the group of object minutiae and the group of registered minutiae are to be rotated around a predetermined point with respect to the other of the two groups of minutiae and a shift by which at least one of the group of object minutiae and the group of registered minutiae are to be parallelly shifted with respect to the other of the two groups of minutiae.